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Development. (1948) Department.

SERIES.

G.O. No. 348

Dated 23.1.48

[Despatch Abstract.]

Subject- Agriculture - Indian Council Agricultural Research - Wheat rust control - Scheme for the breeding of rust resistant wheats for the hill tracts of Madras Province and adjacent states - Forwarded.

Development Department.

Letter Ns. No. 345, dated23.1.48.

To

The Secretary to the Indian Council Agricultural Research, New Delhi.

Sir,

Sub:- Agriculture - Indian Council Agricultural Research - wheat rust control - Scheme for the breeding of rust resistant wheats for the hill tracts of Madras Province and adjacent states - Forwarded -

Ref:- Your letter No. F. 73(6) 47-A, dated 29th September 1947.

I am directed to forward herewith a scheme for the breeding of rust resistant wheats for the hill tracts of the Madras Province and adjacent states. It is proposed to open a substation at Wellington in the Nilgiris. The station will form part of the All India wheat breeding scheme under the control of the Director, Indian Agricultural Research Institute, New Delhi. The Director of Agricultur Madras considers that the scheme should be started in April 194

The expenditure on the scheme is estimated at Rs. 75,360/- recurring for five years and Rs. 47,500/- non-recurring. As wheat is not an important crop in this province, and as the scheme has been sponsored by the Indian Council Agricultural Research the Government of Madras consider that the entire expenditure should be borne by the Council. As the sub-station will be worked under the direct supervision of the Director, Indian Agricultural Research Institute the scales of pay proposed for the staff in the scheme are on the basis applicable to central Government servants.

(Sd) x x .

Copy to the Director of Agriculture.
Copy to Government of*Ministry of Agriculture *India.
New Delhi with reference to their letter No.
F. 5-6/46, dated 28.4.47.
(with a copy of pp. 19-23 c.f.)

/True copy/

Development Department.

Sub:- Agriculture - Indian Council Agriculture Research Scheme for the breeding of rust resistent wheats for the hill tracts of Madras Province and its adjacent tracts.

Ref:- From the Government of India No. F. 5-6/46-PP(SV) dated 27.8.47. Issued as Endorsement No. 83887 A11/47-1, dated 9.9.47.
From the Indian Agr Council Agricultural Research No. F. 73(6) /47-A dated 29.9.47.
Issued as Endorsement No. F. 73 (6)/47-A, dated 29.9.47.
From the Director of Agriculture No. D. 1. 840/47, dated 22.11.1947.

To Assistant Secretary

In July 1947, the Government of India convened a conference at New Delhi to discuss the wheat rust problem and the control measures required to arrest its spread. The Government Mycologist, Coimbatore attended the conference. At that conference the following decisions have been taken relating to the tackling of the problem in this province -

(i) to carryout a survey of areas in South India on which certain grasses are grown, which have been known to carry black rust infection during summer months at least in northern India.

(ii) Rust resistant Varieties for the Nilgiris be evolved and for doing so a sub_station be established in the Nilgiris. This proposals should be incoprorated in the scheme which the Indian Council Agricultural Research are considering.

Item (i) above:- In G.O. Ms. 4076 Development dated 14.8.47, necessary staff was sanctioned for conducting the survey and it is expected to be completed by the end of December 1947.

Item (ii) above:- The Director of Agriculture has now submitted a scheme for the breeding of rust resistant wheats for the hill tracts of Madras province and adjacent States. It is proposed to open a sub-station at Wellington in Nilgiris and it will form part of All India wheat breeding scheme under the control of the Director of Indian Agricultural Research Institute, New Delhi.

Substation The following staff are proposed for the scheme As the ~~substation~~ is to be under the direct control of the Director Indian Agricultural Institute, the scales of pay proposed for the staff are on the basis applicable to Central Government servants.

1. One Asst. wheat breeder (Class II) 200-650
2. Two research assistants on Rs. 150-10_350
3. Two junior Laboratory Assistants on 50-5-100
4. One ~~Assts~~ First Grade Mali on 20-1½-38.
5. one Chaprasi on Rs 16-30.

The expenditure on the scheme is estimated at Rs. 75,360 recurring for five years and Rs. 47,500 non-recurring.

In their letter on p 11 c.f. the Indian Council Agricutlural Research stated that it is intended that the expenditure involved in the scheme will be met on a 50:50 basis between in the provincial Government and Council. The Director of Agriculture suggests that the entire cost may be met by the Indian Council Agriculture Research as wheat is not an important crop in the province and further the scheme has been sponsored by the Indian Agricultural Research because there is a beleief that the Summer wheat of South Indian hills aids the perpetuation and multiplication of rust inoculum which is believed to affect winter Crop of North India, cultivated extensively. The Director of Agriculture's view may be accepted. For orders.

It may be pointed out here that even in schemes entirely financed by the Indian Council Agricultural Research, generally they will be under the control of the provincial Government and the staff are also appointed by the Provincial Government. From the letter of the Indian Council of Agricultural Research on p. 11 c.f. it is clear that the scheme should be run under the auspices of the Provincial Government, through it may form part of the All India wheat Breeding scheme.

The points for consideration are:-

(i) whether the scheme will be run by the provincial Government and the entire cost may be claimed from the Indian Counsil of Agricultural Research or

(ii) whether the scheme will be left to be worked by the Indian Council of Agricultural Research under the control of the Indian Agricultural Research Institute. New Delhi as suggested by the Director of Agriculture.

As the scheme aims at breeding diseases resistant varieties of wheat which may also be helfpful to the growers of wheat in the Nilgiris and Puleny hills, it is for orders whether the course suggested at item (i) above will be adopted. If so, the staff and their scales of pay proposed have to be suitably altered in conformity with the existing scales of pay of the Provincial Government.

After orders are passed in case may be sent to Finance Department for remarks.

The Government of India may run the scheme themselves just as they are running breeding schemes for sugarcane and tobacco. This apparently is the Director of Agriculture's intention as he has provided staff on the G. of I. scales of pay. We may forward the scheme to Government of India and tell them so.

* Council.

(Sd) x x x/18.12.47.

/True copy/

Finance (E II) Department.

The proposal of Dev't. at A on p. 3 ~~above~~ ante may be agreed to in Finance.

(Sd) x x x/10-1-48.

/True copy/

Development Department.

To Assistant Secretary:-

(Notes from p. 1 above may be perused.)

Finance Department have agreed with this Department's view at 'A' on p. 3 ~~above~~ ante A draft letter forwarding the scheme is submitted for approval.

(Issued as Lr. Ms. No. 345, dated 23.1.48.)

(Sd) x x/22.11.48.

/True copy/

WHEAT RUSTS AND THEIR CONTROL

I. INTRODUCTION.

The Ceareal rusts - a source of loss all over the world assessment of damage.

Rusts of cereals are potential causes of great destruction in all ceareal-growing regions of the world; under favourable conditions one or other of the three rusts, especially the black and yellow rusts, is capable of more or less totally destroying the crop, as has been the case this year in Central and Peninsular India.

In America, Canada and other countries damage done by rusts has been carefully assessed. For example in 1935, the U.S.A. had estimated an yield of 731,045,000 bushels of wheat but due to a rust epidemic, seasonal conditions being favourable, the total yield harvested was only 599,000,000 bushels, i.e. a loss of 132,045,000 bushels; the same year in Canada the difference between the estimated yeild and the yield actually harvested was 91,029,000 bushels; here also the loss was due to damage done by rust. Gussov estimates the average annual loss in Canada to be over £ 5000,000, and according to Greaney, Canada loses annually, 40,000,000 from the same cause. Mehta in India considers the loss to be about Rs. 60,000,000. In Kenya Burton considers rust to be "the limiting factor in production" of wheat.

How rust originates and spreads: Rust is a parasitic organism of a very complex nature, belonging to the vegetable kingdom; it can survive only on its living plant hosts; this parasite is highly specialised; take the example of black rust of wheat and that of oats: both are caused by Puccinia graminis but the wheat rust will not infect oats and vice versa. For the development of disease, three factors are usually involved viz, the pathogen, the host and suitable climatic conditions; all these three factors combined together bring about an epyphytotic i.e. an apidemic, and therefore in the study of an epidemic each of these factors has to be carefully studied. For the development of an epidemic is required an "interaction of a number of environmental factors operating in proper sequence over a long period of time"; for these reasons the problem of epidemiology of the disease is "extremely intricate and puzzling" according to stakman. He states "Nevertheless, as a result of extensive investigations by the United States Department of Agriculture and the Minnesota Agricultural Experiment Station during the past twenty years, many of the basic factors governing the Development of epidemics are now known, although nearly every major epidemic that has been studied has followed a different course". In India also we have to study "the basic factors govering the development of epidemics" and the course they follow.

On wheat there are three rusts, the black, yellow and brown, of which the first two are considered to be very important, in India. Wheat rusts are not ordinarily speed borne; a wheat plant gets infected by means of the uredospores, or what are known as repeating spores or red spores; successive generations of such spores are produced on the plants and thus the disease spreads from plant to plant and field to field.

Dissemination: Large numbers of spores are carried by wind

currents which help in the dissemination of the pathogen. In the spread of rust, man and insects do not seem to play an important part. There is enough evidence to show that new races of rust are disseminated widely by wind and thereby become established over large areas; for example, it has been shown that race 56 of the wheat black rust gifgungus was not known in America prior to 1938, it had been isolated from all states from which rusted wheat was obtained in the U.S., t extending from the Pacific coast to the Atlantic and from Northern-Mexico into Canada. The wind was so effective an agent of dissemination that a little initial inoculum, at least relative to the amount that developed subsequently, increased in various infection centres until it became so large as to enable a new physiologic race to become the most prevalent and most widely distributed in North America.

Alternate and collateral hosts:

The black rust fungus in order to complete its life cycle has to spend a part of its existence on a host other than wheat viz. the barberry i.e., the fungus has an "alternate host" besides wheat. In many parts of the world the two stages of this fungus on wheat are also found on other hosts such as grasses and these hosts are known as collateral hosts.

Physiologic races:

The three rusts of wheat can be readily distinguished from each other, but each rust has distinct entities or groups of forms which cannot be distinguished from each other on a morphological basis but still they have different parasitic capabilities black rust of wheat has got about 200 such forms, each of which is known as a Physilogic race and is given a distinguishing number.

Control Measures: From the study of rust, control measures that are generally recommended are -

(a) the eradication of alternate hosts and collateral hosts;
(b) destruction of "volunteer wheats" i.e. plants from self sown seeds and avoidance of "out-of-season" wheat crops;
(c) use of sulphur and other fungicides;
(d) certain fertilizers, especially nitrogenous ones have been known to make plants more susceptible to disease whereas other fertilizers are known to make the plant more resistant to rust infection;
(e) cultural practices might influence the intensity of rust-infection; but the most important method of control is the breeding of rust resistant varieties.

A BRIEF ACCOUNT OF WORK DONE IN THE MOST IMPORTANT WHEAT GROWING COUNTRIES ON THE STUDY AND CONTROL OF WHEAT RUST

The Work done in other countries on wheat rusts is briefly given below.

United States: The prevalent rusts are black and brown.

Black rust is perpetuated in the accidial stage on barberrics, the alternate host of this rust. In the year 1917 Stakman discovered the presence of physiologic races within black rust. Since then a large number of races have been found, new ones arising out of hybridization on barberries or by mutation. Billions of barberry bushes have been destroyed at enormous cost. Every year new improved varieties resistant to rust are being evolved. It has been reported that there is a seasonal interchange of rust between the United States and Mexico. In the U.S.A. a programme for wheat breeding for rust control was initiated as early as 1911.

2. Canada: Black and brown rusts predominate, yellow being confined to the hills.

According to Buller and Craigie south winds blow the spores of black rust into Canada. Infected barberries supply local inoculum and also produce new physiologic races. In addition to the eradication of barberries at considerable expense, systematic breeding of resistant varieties has been in progress since 1922. New varieties are evolved every 3-4 years, to take the place of old ones in view of changing pjysiologic races.

3. Australia. Black rust predominates, although brown is also found. Rust studies were started in 1921 and Waterhouse found nine races of black rust. Breeding of resistant varieties has been in progress since the last twenty years and recently the eradication of barberries has been suggested.

4. U.S.S.R. : All the three rusts are found in different parts of the country. Shitikova - Roussakova recorded the overwintering of black and brown rusts in North Manchuria. Overwintering of yellow has been reported by Roussakov. In Russia there has been a programme for wheat breeding since 1930.

III. DISSEMINATION AND EPIDEMIOLOGY OF RUSTS.

Direct evidence of the dissemination of black rust of cereals and grasses to very long distances by air currents has been obtained especially be American and Canadian workers. In connection with the long distance dissemination of spores it is not possible to locate the origin of the inoculum. "Under most conditions it is almost impossible to determine whether the spores originated in the immediate vicinity, or have been carried by the wind from remote places, irrespective of the altitude at which they have been caught Ukkelberg has calculated that if "uredospores of Puccinia graministritici (black rust of wheat) reached an altitude of 5,000 feet their dispersal distance in a 30 mile wind would be about 1,100 miles. Both Lambert and Stakman have shown "that under certain conditions rust spores of Puccinia Graminis, are blown from the far south into the Dakotas and Minnesota, travelling more than 1000 miles in about two days and up in Canada in a short time thereafter."

The spores have been found to remain viable in spite of "vicissitudes of wind dissemination". Russokov has shown that uredospores of the black rust fungus "can be carried 50-250 km. over the sea without losing their viability".

Waterhouse considers that wheat stem rust or black rust may have been introduced in Australia by "air-borne uredospores from cereal crops in India or elsewhere"; ba-

barberry, the alternate host of black rust, was introduced in Australia much after black rust was first found on wheat; and "it is known that rust spores have been carried thousands of miles by wind, frequently associated with atmospheric dust." He has established the presence of nine physiologic races of black rust in Australia and New Zealand. From the distribution of these races over a period of several years he finds that there is a distinct change in the rust flora commencing in the 1926 season and that the changes in Australia and New Zealand are "parallel", the transport of uredospores taking place across the Tasman Sea.

Roussakov and Shitikova-Roussakova are of opinion that wheat rusts (black and brown) are probably introduced into the Amur region of Siberia by wind-borne spores from North Manchuria, where they over-wintered in the uredial stage". Chabrolin believes that black rust in Tunis in Africa "must be re-introduced every year from outside sources, and it seems likely that spores are probably ~~outside sources, and it seems likely that spores are probbably outside~~ blown across the Mediterranean Sea from Sicily and Sardinia.

Wind-borne spores of yellow rust carried from Washington, Idaho and Montana are considered by Sanford and Broadfoot to be the cause of the annual recurrence of the rust in Alberta, Canada.

Bailey, Craigie, Greaney and other Canadian workers have shown that black and leaf rusts do not overwinter in Manitoba, and that their uredospores are "always present in the air in advance of the infection of the crop", and therefore, they consider that these two rusts of wheat are regularly introduced into Manitoba by wind-borne spores from United States.

Mehta has shown that in the plains of India rust spores do not survive the summer and therefore, he concludes that the infection must be coming from other sources.

Rapidity of the spread of the infection:

The black rust pustule may contain 50 to 400 thousand spores; enough to infect almost an acre of the wheat crop; each of the spores is capable of infecting a healthy plant and producing successive generations of spores in a week's time. The infected plant has many such pustules and therefore the number of such spores developed on a plant may run into many millions.

IV. CONTROL MEASURES.

1. Eradication and "clean-up"

The question as to how the rust is carried over from season to season has to be considered in evolving control measures. Black rust spends one part of its life history on the wheat plant, barley plant, or some wild grasses; and then completes its life cycle on barberries. Teleutospore

(the black spores or winter spores) produced on wheat or barley lie dormant in cold countries till the end of winter when they are capable of infecting tender leaves of barberries. On this "alternate host" the cluster-cup bearing stage is produced. Spores produced in these cups infect young wheat plants which is turn develop the uredospores (summer spores or red spores) and later the teleutospores.

Barberries therefore serve as foci of infection for the new crop in spring.

The connection between the aecidiospores, (spores from the cluster-cups,) disseminated from barberries, and the occurrence of local epiphytotics and wide-spread regional epiphytotics has been well established.

It would naturally be therefore, thought that the best way of controlling rust on wheat would be to eradicate the alternate host so as to prevent the parasite from completing its life cycle.

Therefore in 1918 United States Department of Agriculture in co-operation with other States started a barberry-eradicating campaign. In two years about 16,000,000 bushes and seedlings were destroyed; however "in 1927, 10 years after the campaign started, 1688,554 bushes, sprouts and seedlings were found. During May and June of each year a large proportion of the remaining bushes were rusted. One heavily rusted barberry bush may bear about 70,000,000 aeciopores."

In Australia and India, however, barberries do not play an important part in the seasonal dissemination of rust on wheat, because the problem is not one of over-wintering but of over-summering.

In Australia the living rust in the uredospore state is present on sporadic crop plants or susceptible grasses all the year round. This inoculum is responsible for initiating the rust attacks in the crop. Not long ago it was stated that complete control of wheat stem rust could be had if only agreement could be reached, whereby all growers every-where in Australia undertook to grow no wheat for one particular season, say from April to December. However it will be seen from accmulated evidence that this would not solve the problems." Waterhouse has made field collections of black rust and brown rust of wheat and black rust of oats month by month for about 15 years and he observes, "Attention is drawn to the fact that opportunities for collecting rusted material have been distinctly limited. It is certain, much more rust was available in the field than is indicated by the collections submitted for examination". The rusted material obtained during the non-wheat-growing season (late summer and autumn) has consisted mainly of "volunteer" wheat or oat plants as the case may be but some of the specimens were wild grasses. Some came from the wheat belt. Others were collected in regions of better rainfall, e.g. on the coast. But the latter could easily serve as foci whence infection could spread to the main wheat growing areas. In considerations of rust control there can be no possibility of eradication by simply not growing a crop for a season. Other means must be sought".

2. Sulphur and other fungicides:

Work done in the U.S.A. and Canada shows that

gically indistinguishable from each other, which vary in their ability to attack different varieities of wheat. Early breeders were puzzled by the failure of certain varieties to maintain their resistance from year to year, and in different localities. When however, Stakman and Piemeisel demonstrated the existance of physiologic races in Puccinia graminis tritici (the black rust fungus) in 1917, the reason for these apparent breakdowns of resistance became clear. Most wheat varieties are resistant only to certain physiologic forms and the particular forms present vary from locality to locality and from year to year.

Nearly 200 forms of black rust are now known, and similarly physiologic races exist in the brown and yellow rusts also. New forms may arise by hybridization or mutation. While the existence of these numerous physiologic races renders the task of breeding rust-resistant wheats an arduous one, encouraging features also occur. These are the discovery that certain varieties which are susceptible in the seedling stage exhibit considerable resistance when mature, and that governed by a single genetic factor.

Considerable success has attended the attempts to breed black rust resistant wheats and varieties such as Kanred, Hope, Ceres, Larquillo, Thatcher and Renown have proved very useful. Brown rust-resistant strains have also been bred and some combine resistance to both the black and the brown rusts. As indicated earlier, wheat breeding for rust resistance has also been in progress in many other countries. Recent developments include the use of the less well-known specifes of wheat (Triticum) and of allied genera as resistant parents for hybridization, work.

V. WORK DONE IN INDIA.

Our present knowledge of the rusts of cereals in India is entirely due to the researches carried out by Mehta during the last almost two decades. To him goes the credit of establishing the presence of physiologic races, which is being made practical use of in breeding resistant varieties. Formerly it was taken for granted that barberries found in the Simla Hills were responsible for the spread of rust on wheat but Mehta has shown that these barberries play a very minor part in the dissemination of wheat black rust.

All the three rusts of wheat are found in India. Black and yellow rusts also infect barley. Black rust is found in all parts of the country, including the hill as well as the plains. The brown also occurs everywhere, excepting in a small part of peninsular India. Yellow rust however has not been observed in the plains of peninsular India.

Physiological studies as well as the distribution of each of the three rusts in this country show that black rust is able to with tand warm wheather better than yellow rust, the latter thrives better under comparatively cool conditions; the brown rust occupies an intermiediate position. As a consequence of the temperatures prevailing during the growing season of wheat (for instance, the Punjab has a comparatively lower temperature during the greater part of this

precipitated sulpnur is toxic to rust spores. Lambert and Stakman used 30 lbs. of sulphur per acre of wheat and found that, in some experiments, one application virtually controlled rust, while in others, five applications where ineffective Greaney observed that once a plant was infected, subsequent applications of sulphur served only to prevent further infections.

3. Effect of fertilizers and cultural practices.

Work done outside India has indicated quite clearly that, in general, nitrogenous fertilizers tend to increase susceptibility of the wheat plant, while phosphate has the opposite effect. Experiments in which various proportions of N,P, and K were applied showed that rust was more severe when K was deficient in the ratio. As a result of such investigations and observations it is now generally accepted that rust may be reduced in severity be reducing the proportion of N in the N:P:K: ratio.

Experiments have also been carried out with minor elements and miscellaneous substances but these have not yeilded promising results.

Cultural practices have, generally speaking, not been shown to have any direct effect on rust incidence except that practices which tend to promote early maturity usually help the plants to escape the most destructive rust. There are indications that rust may be unusually destructive in irrigated wheat.

4. Breeding:

Where resistant varieties exist or have been bred these constitute the simplest and least expensive method of disease control for they ential no additional expenditure or work to the grower.

Chester (1946) in his comprehensive book on cereal rusts states: "Adjustment of time of sowing, fertilization, destruction of volunteer cereal plants, applications of fungicides, - these are but adjuncts to the fundamental solution of the cereal rust problem: the breeding of cereal varieties that are resistant to rust, - at once the most certain and effective, and the most economical means of checking the revages of the cereal rusts". Breeding of wheat, pioneer work of Farrer in Australia at the close of the last century; this work was so successful that feeding for rust resistance as a method of rust control was well esablished in Australia. In the early years of this century, Biffen at Cambridge applie the newly rediscovered Mendelian principles of heredity to breeding Wheat for resistance to yellow rust, the only rust which is of economic importance in England. This was followed by very intensive work in the United States of America and in Canada; this dealth mainly with the black or stem rust which swept America in 1938 and destroyed the famous black-rust resistance to brown rust has also been taken up seriously.

The breeding of rust resistance wheats has been found to be difficult and slow. One circumstance contributing to this in the earlier work was the lack of knowledge of the existence in the rusts, of physiologic races, morpholo-

period), the yellow and brown are common in the Punjab, all the three are equally common in U.P. and Bihar; and black rust predominate in the plains of C.P. and Deccan. These rusts are capable of doing considerable damage, particularly yellow and black, in the provinces where they commonly occur, their intensity ~~depdns~~ depends on the prevailing wheather conditions.

In the plains, the summer heat that follows the harvest, kills all the uredospores of these rusts. Consequently, there is no local source of infection when the crop is sown in the plains.

In the hills, on the other hand, all the three rusts have been found to over-summer on stubble, volunteer wheat and "out-of-season" crops, at different altitudes ranging from 4000 to 8000 ft. above sea level. This has been confirmed by repeated observations extending over a period of 20 years. Crops in the hills get infected rather early in the season in the neighbourhood of these rusted volunteer wheat plants and the spores are then disseminated by winds to the foot-hills and the plains causing fresh outbreaks.

In general, according to Mehta, rusts appear earlier at places in the foot-hills than those situated farther away in the plains.

Spores of all the three rusts have been caught on aeroscope slides at a large number of stations in the plains before the local appearance of rusts, showing that the spores are introduced by wind. Mehta, from his study of wind trajectories correlated with spore showers, concludes that the air currents had either come from the hills or passed over areas where rust had appeared earlier.

In addition to oversummering in the hills on volunteer wheat, two important foci exist according to Mehta; where, due to early crops, there is plenty of rust every year at the time ~~is~~ sown in the neighbouring plains. These are central Nepal in the north and the Nilgiri and Palni hills in the south.

~~In addition to oversummering~~
It should not be taken from what has been said above that every locality in the plains gets infection direct from the hills. In fact, after the intiial infection of a few plants and other fields in that locality, under favourable weather conditions. Later on, infection may spread to other places in the plains as a result of air-dissemination of spores. Wild grasses have been found to be collateral hosts of some of the cereal rusts in other countries and a considerable amount of information is Canada, United States and Australia. In India only the black rust found on Bromus patulus and Brachypodium sylvaticum has been definitely shown by Mehta to be the same as that on wheat. Infested Bromus patulus has been found at several places in Kashmir and the Simla hills. These grasses are annuals and their growing season is the same as that of wheat. No oversummering of rusts has, however, been noticed on these grasses.

The study of physiologic races carried out by Mehta during the last 20 years has so far resulted in the identificatinn of nine races of black rust, eight of brown

and ten of yellow, some of which have not been found outside India. It is probable there may be other races in this co try which have not been identified as yet. Further, it very probable that more races may be evolved as a result of hybridization and mutation or may be in-troduced from other countries. In Canada new strains of brown rust were fo in 1946 which caused heavy infection of Regent Wheat and oth resistant varieties.

Mehta from his extensive study of wheat rusts in India makes the following recommendation.

"It is necessary therefore, that in the meanwhile wheat and barley crops should be saved from diverting epidemics, year after year, caused by all the three rus taken together, by controlling the inoculum at the source, i.e. in the hills. Considering the huge loss of Rs. 60 millions or so per year to these crops caused by rusts, the writer is strongly of the opinion that a good deal of damage could be mitigated by rigorous destruction of self-sown plants and tillers, which 'carrry over' the rusts, 1-2 months before sowings in the hills. This method is thoroughly practicable because of very small individual holding in the hills, where the crops in question are grown on small and narrow terraces".

Theoretically his recommendation for saving the "huge loss of Rs. 60, millions or so per year" (it is not known how he has arrived at this figure) may be soun but the question to be considered is "Is the measure recomme ed practicable, both physically and economically"? When we consider the "clean-up of self-sown wheat" we have also t dosider the probable existence of grasses on the hills whic are affected by the same rusts as wheat and barley; if the are out-of-season and self-sown wheats certainly there are also out-of-season and self-sown grasses which are of equal Importance as centres or foci of infection as the wheat and barley plant; even granting that these gasses be not centre of of infection there is the important question of differe tiating young wheat plants from those of some of the grasse which even experts at that stage may fail to identify; th self-sown wheat plants are not always to be found on the bea ten tracks of the hills; they will be scattered all over, perhaps more often than not in very inaccessible places a a thorough search for these plants even if we do not include grasses, would be impossible. Another factor that militates against a thorough clean up is the time factor. The clean-up has to be done between the harvest of one season and the sowing of the next, i.e. within the three months, Ju ly to September; this period is the monsoon season and ther fore the question arises for how many days during this sea son clean-up would be physically possible on the hills. The total number of days in these three months when even the easily accessible places can be carefully examined would be considerably reduced. Taking these facts into considerat the number of men that would be required for this clean-up would be very large indeed and so would be the expece. T question therefore naturally arises would be the expence. The question therefore naturally arises would this clean- u even yeild the cost spent on removing the self-sown plants if and whether it would give definite results.

It is evident that Mehta has not found all the foci of infection, and he cannot be blamed for it, looking to the strength of the staff he had. He says in his monograph" ("In general it may be stated that this rust (black rust) has been found to oversummer in almost all the hills visited excepting Pachmarihi (Central Provinces)". In reply to an inquiry from the Mycologist to Gowlior State Mehta said "The early out break (November 15) is very suggestive of a focus nearby. You know oversummering of black rust is likely even it altitude of 3,000 ft. or so."

For Pensular India Mehta recommends suspending "only the cultivation of the first crop of wheat and barley (sown in April-June) in the Nilgiri and Palni hills"; "By far the best effective method of control would be the suspension of wheat and barley cultivation for two to three years in the hills, at altitudes of 3,000 ft. and above, where rusts are able to oversummer". Mehta in making this recommendation appears to have over looked the existence of other sources or foci of infection such as volunteer wheats and barley and wild grasses.

It may be argued that if large part of the source of inoculum in the shape of "cut-of-season crop" is removed the infection would be materially reduced; that the infection ~~would~~ from volunteer plants and wild grasses will not be so much as to cause an epidemic; and that the absence of the "out-of-season crop" will considerably delay appearance on account of the crops in the plains. This year we have authentic information of rust having appeared in Gwalior and Central India by the middle of November Mehta therefore suspects" a focus nearby"; so evidently this focus was not the "out-of-season crop" grown in the Nilgiri and Palni hills. We have seen that a black rust potule may contain 50-400 thousand spores, enough to infect almost an acre of wheat, and therefore even if no "out-of-season" crop is cultivated the infected volunteer wheats remain potential foci ~~culti~~ of the infection all that perhaps can be expected from not growing the "out-of-season" crop would be that the infection might be delayed; but when the infection can come as early as the middle of November the delay of the infection by two or three weeks ~~of November the delay of the infection by~~ would not materially help in warding off an epidemic. On this matter one cannot be dogmatic and herefore it would be advisable to consults the mycologists of the States and Provinces which are concerned with this problem of not growing the "out-of-season" wheat and barley.

Gaps in our knowledge.

The knowledge we have at present regarding the rust problem is not wholly complete; e.g. we do not know wheat are the predominent physiologic races on volunteer plants and collateral hosts month by month. In Australia race 34 suddenly appeared in 1926 and since then it has become a predominant race but; in India this race was first observed by Mehta about 1941; there is not much information available regarding the presence of collateral hosts and alternate hosts in the various hills of India; there has been a lack of systematic study of the epidemiology of rust; the probability of infection coming from neighbouring countries like Afghanistan and Persia have not been systematically consdered.

Mixed Cropping. We have no reliable data regarding the effect of mixed cropping on the incidence of rust and on the value of the crops. It is worth investigating to what extent it constitutes and insurance against loss owing to epiphytotics ?

Breedying.

Although it was realised in the first decade of this country that breding for resistance against rust was necessary and work was actually started at Bombay, Cawnpore and Pusa, not much progress was possible because of reasons which have already been mentioned when discussing the work done in other countries. However, certain of the strains prossess a fair measure of mature resistance and in the recent severe epidemic the following wheats have been reported to have fared well. I.P. 52, I P. 4, I.P. 165 and Pb.C 591. Several of the new 'Pusa' wheat which were under trial have also yielded well in spite of the epidemic.

It is necessary to lay stress on the fact that the work of breeding resistant varieties based on the knowledge of work was of a haphazard nature, selection having been made on the behaviour of wheat varieties at a certain place in any one year without reference to the physiologic races which may be present in the locality. Systematic breeding of rust resistant varieties was started 12 years back based on the number of physiologic races found by Mehta. Since then, some more races have been found. Work was started at Simla, in Bombat and in the Central Provinces. At Simla the aims is to secure resistance to all the three rusts; and progenies of crosses between Indian and exotic types are tested both, in the seedling and adult stages. High resistance to all the physiologic races and has been achieved separately for each rust, and the work is at a stage when synthesis of resistance to all the three rusts simultaneously is being attempted by means of a double cross ? simple work is intended to provide the scheme submitted by the Indian Agricultural Research Institute, relating to the plains was delayed by the Imperial Council of Agricultural Research, by whom the scheme is financed.)

races is only of ... origin. All ... nervous

In the Central Provinces and Bombay, the work is concerned with resistances to black rust only which is ordinarily the dominent rust in those Provinces.

FURTHER WORK REQUIRED TO BE DONE IN INDIA WITH A VIEW TO CONTROL RUST.

Assessment of damage: Controlled experiments should be carried out to assess the demage done by rusts at different stages of growth of the wheat plant. Provinces, States and the I.A.R.I. can draw up a common programme of work and carry out the necessary experiment. The results can be collated by the Statistician at the I.A.R.I. Farm Superintendents in the Provinces and States should carry out these experiments and no extra staff is needed. At the I.A.R.I. one Research Assistant and one 1st Grade Mali (Kamdar) will be required.

Dissemination: A more detailed study of the dissemination of the rusts should be carried out. The study should include

the study or rusts found on wild and cultivated grasses on the hills of India. A search should also be made for alternate hosts viz., barberries be and Thaliotrum: in the Nilgiri and Palni hills this search should be done by the Mycologists of Madras and Mysore; in the U.P., & and by the I.A.R.I. Agricultural Assistants in the Provinces and States can make the necessary collections in the course of their touring duties and hence no provision for staff is made

& and the Punjab hills by the provincial Mycologists in the Simla hills

Epiphytotics: If we can correlate the effect of a sequence of climatic factors with the incidence of rust and thereby be able to prophylactic measures as our study of control measures proves to be satisfactory. The effect of temperature, rainfall, dew, clouds etc have to be critically studied with the help of the following instruments; (a) thermohygrograph, (b) anemograph, (c) automatic raingauge (d) dew recorder, (e) sun-shine recorder. The places provisionally selected are Khanewal, Karnal, Cawnpore, Gorakhpur, Pusa, Hoshangabad, Jubbulpore, Indore, Dharwar, Amreli (Gujerat), Himayatsagar (Hyderabad, Deccan), Sakrand (Sind), Simla. At these farms there will also be rust nurseries.

Observations will be made by the Provincial and State staff at the farms, except at Simla, Karnal and Pusa, where the observations will be done by I.A.R.I. staff. The co-ordination of the observations on the intensity of rust at these stations will be taken up by the I.A.R.I. No extra staff is needed. Some instruments will be available at most of the places selected for this study. It would be necessary to provide those that are not present.

Physiologic Races: For the study of physiologic races it is suggested to divide the country into three groups viz. Group A Bombay, Hyderabad (Deccan), Madras and Mysore, Group B. Central Provinces, Central India and Rajputana. Group C. N.W.F.P., Kashmir, Sind, Baluchistan, Punjab, U.P. and Bihar.

Each of these groups will test rust samples from its area test seedling and adult resistance of wheat cultures and hybrides required by the provinces and States included in the group.

Group A. The work will be in charge of the Plant Pathologist to the Government of Bombay and will be done at Mahableshwar were a laboratory exists; a green house may be necessary for the study of physiologic races. Three assistants will be required.

Group B: The work will be in charge of the Mycologist to the Government of C.P. A rust laboratory and a green house will have to be provided at Pachmarhi. Three assistants will be required.

Group C: The work at present being done at the Rust Research Station at Simla and Agra by Dr. Mehta will be continued at Simla and Delhi, facilities being increased to test 250 samples every year. The I.A.R.I. will take up this work in these centres.

For doing the seedling and adult resistance tests for provinces and States of this group an additional green house at Simla will be required; at Delhi two small greenhouses will have to be provided. Dr. Mehta will be

associated with the work to be carried out at Simla and Delhi for Group C.

Staff:

(a) Existing under present Scheme financed by the Government of India through the I.C.A.R.

1. 1 Assistant Mycologist Class II Officer.
2. 2 Research Assistants.
3. 1 Steno-Typist and Clerk.
4. 3 Laboratory-bearers.
5. 1 Peon.
6. 1 Sweeper.
7. 1 Chowkidar.

(b) Additional Staff Required:

1. 3 Research Assistants.
2. 1 Junior-Laboratory Assistant.
3. 1 II-Grade Mali.

Rust nurseries should be established in different parts of India where there are Agricultural Famrs. This will not ental any extra expense. The following places are provisionally suggested.

Group A: Niphad, Ahmadnagar, Dhond, Ponna, Mahableshwar, Satara, Arbhavi, Bijapur, Belgaum, Dharwara, Raniben nur, Gudag and other places as recommed by the Provincial Mycologist, Bombay.

Bellary, Guntur and some other places recommed by the Mycologist, Madras.

Chituldroog, Birur, Hassan, Chikmaglur, Mandya, Tarikare and other places recommended by the Mycologist, Mysore State.

Himayateagar and some other places recommended by the Mycologist, Hyderabad State.

Group B. Jubbulpore, Damoh, Dindori, Khandwa, Nagpur, Betul, Basin, Hoshangabad and other places which can be recommended by the Mycologist, C.P.

Indore, Ajmere, Sriganganagar (Bikaner)? Abu, Jaipure, and other places recommended by local Mycologists of the area.

Group C. Tarnab, Abbotabad, Mansehra, Marden or Bannu, Haripur, Sakrand, Sukkur, Larkana, Hyderabad, Srinagar, Jammu, Baramula.

Places in Punjab, U.P. and Bihar in consultatic with the Mycologists concerned.

Trial of sulphur and other fungicides and the economics of their use.

A detailed study of controlling rust by the use of sulphur and other fungicidal dusts is recommended. These experiments can be done by Provincial and State Mycologists a and by the I.A.R.I. according to a scheme prepared by the statistician.

The farms where the Provinces and States should do this work will be settled in consultation with the Mycologists concerned. No additional staff is needed.

The I.A.R.I. proposes to do the work at Simla, Karnal, Pusa and Hoshangabad. One 1st Grade Mali and one 2nd Grade Mali will be required at Simla and Karnal. The Research Assistant provided for "Assessment of damage" will also look after this work. At Simla it will be necessary to lease two acres of land near the Rust Research Laboratory; it is expected that receipts from the produce of the land will meet the normal expenditure, like ploughing, manuring and cost of seed.

A suitable dusting machine will be devised and first tested at the I.A.R.I.; if successful it will then be tried out in the Provinces and States.

At Karnal Sub-station 10 acres of land will be used for this experiment.

At Pusa Sub-station five acres of land will be used for this

Effect of fertilizers and cultural practices-mixed cropping:

The incidence and intensity of rust on wheat varities manured with varying proportions of N, P and K should be studied to find out to what extent applications of those affect the incidence of rust and the yield of wheat; the effect of varying amounts of irrigation and different dates of sowing should also be studied.

In many parts of India some crops are sown as mixed crops. While it is unlikely that such a system can affect the intensity of rust infection (rust being wind-borne), there is the possibility that it is a form of insurance against lose of one crop (wheat). As we have not yet got many rust resistant varieties and it may take some cover the whole of the wheat are under such cropping is or is not more paying, taken over a period of years. Experiments should therefore, be laid out to work out the economics of growing wheat as a pure and as mixed crop. The work will be done at Karnal in the first instance.

Staff required:

1. Research Assistant.

2. Fieldmen.

Breeding:

Work on breeding wheats resistant to the rusts requires to greately extended and intensified. The main line of work will be (a) Study of wheat varietal collec-

tions for rust resistance; (b) Hybridization between suitaable varieties to comibe a high degree of rust resistance with other agronomically desirable qualities; (c) breading work with the progenies of these crosses to obtain the desired strains. The work should be carried out at:

1. Lyallpur for the North-West portion of the great North Indian plains.

2. Cawnpore for the North-Eastern portion of the great North Indian Plain.

3. Hoshangabad for the black soil areas of the C.P. and adjoining areas.

4. Niphad for Bombay Province.

5. Indore for the durum wheat area of C.I. and Rajputana.

6. Simla for the North Indian Hills.

7. I.A.R.I. for the study of techniques.

Assuming that there is already a section for wheat breeding at each of the centres, the additional staff required at each place will be:

(a) One Class II Officer.
(b) Two Research Assistants.
(c) Two Junior-Laboratory Assistants (Fieldman's grade.)
(d) One 1st Grade Mali.

At Hoshangabad and Simla staff and facilities for what breeding are already available under schemes financed by the Indian Council of Agricultural Research. These schmemes are, however, due to expire shortly. If they are continued provision for staff at these places will not be necessary.

The Indian Agricultural Research Institute can held with varieties known to be rust-resistant for use as parents for hybridization.

Estimate of the total expenditure involved.

1. Assessment of damage (at I.A.R.I.)

1. 1 Research Assistant (150-10-300)	Rs. 1800
2. 1 1st Grade Mali (20-3/2-35)	240
3. Dearness and other Allowances.	600
	2640

II. Dissemination-Nil.

III. Epiphytotics- Staff nil. Some instrumements will be needed.

IV. Physiologic Race
Provinces
Group A.

1. 3 Research Assistants (150-10-350.	Rs. 5,400-
2. Dearness and other Allowances.	1,200-
	6,600-

3. 4 Green House will be required at Mahableshwar.

Group B.

1. 3 Research Assistants. (150-10-350)
2. Dearness and other allowances.

Rs. 5,400-
1,200-

6,600

3. A Rust Laboratory and a Green-house will be required at Pacharhi.

For purposes of calculation, the existing central grades have been used. These will have to be modified in the light of any orders that the Government of India may pass on the basis of the Central Pay Commission's recommendations; modification may also be necessary for staff employed by Provinces and States.

Group C: I.A.R.I. Recurring.

Under existing Scheme financed by Government of India through the I.C.A.R.

1. 1 Class II Officer (200-15-350-20-650)	Rs. 2400-
2. 2 Research Assistants (150-10-350)	3600-
3. 1 Steno-typist and clerk. (100-5-125)	1200-
4. 3 laboratory bearers. (20-3/2-45)	720-
5. 1 peon (14/-)	168-
6. 1 Sweeper (14/-)	168-
7. 1 Chowkidar (14/-)	
8. Dearness and other allowances	
9. Contingencies.	
10-T.A.	

Additional staff required:

1. 3 Research Assistants (150-10-350)	5,400/-
2. 1 Junior Laboratory Assistant (50-100)	600/-
3. 1 II Grade Mali (Kamdar) (15-1-20)	180/-
4. T.A.	1,500/-
5. Contingencies.	1,000/-
6. Dearness and other allowances.	2,000/-
	10,680/-

Non-recurrings:

1. 1 green house at Simla.	15,000
2. 2 Small green houses at Delhi.	50,000
3. Equipment.	1,000.
	66,000/-

V. Trial of sulphur and other fungicides and their economics.

1. Lease of 2 acres of land at Simla.	500/-
2. 1 1St. grade Mali (Kamdar) (20-3/2-35)	240/-
3. 1 2nd. grade mali (Kamdar) (20-3/2-35)	180/-
4. Dearness and other allowances.	500/-
5. T.A.	500/-
6. Cost of fungicides and appliances.	1000/-
	2,920/-

Non-recurring.

1. 1 Special Dusting machine.	10,000/-

The Research Assistant provided for "Assessment of damage" will also look after this work.

VI Effect of fertilizers, mixed cropping, I.A.R.I.

1- 1 Research Assistant (150-10-350)	1,800/-
2. 2 Fieldmen (40-100)	960/-
3. Dearness and other allowances.	500/-
	3,260/-

II Breeding (for 1 station.)

1. 1 Assistant Wheat Breeder (Class II) (200-15-350-20-6 50)	2,400/-
2. 2 Research Assistants (150-10-350)	3,600/-
3. 2 Junior Laboratory Assistants (50-100)	1,200/
4. 1 1st grade mali (Kamdar) (20-35)	240/-
5. T.A.	500/-
6. Dearness and other allowances.	1,500/-
7. Contingencies.	1,000/-
	10,440/-
For 5 stations.	52,200/-

At Hoshangabad and Simla staff and facilities for wheat breeding are already available under schemes financed by the I.C.A.R. If these schemses are discontinued, it would be necessary to make provision for these two stations also.

VII. To co-ordinate the work on the various aspects mentioned above a statistician (Class II) is required at the I.A.R.I.

1 Statistician (Class II) (200-15-350-20-650)	Rs. 2,400/-
1 peon (14/-)	Rs. 168/-
Dearness and other allowances.	Rs. 500/-
	3,068/-

It is not possible to estimate the cost of non-recurring expenses like buildings etc. in the provinces and States. It is anticipated that these will be provided by the Provincial and States authorities concerned.

Grand total:	1,01,692/-
Recurring.	76,000/-
Non-recurring.	1,77,692/-

/True copy/

Office Assistant
~~Superintendent~~,
I.S.L.
Madras Record Office.

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